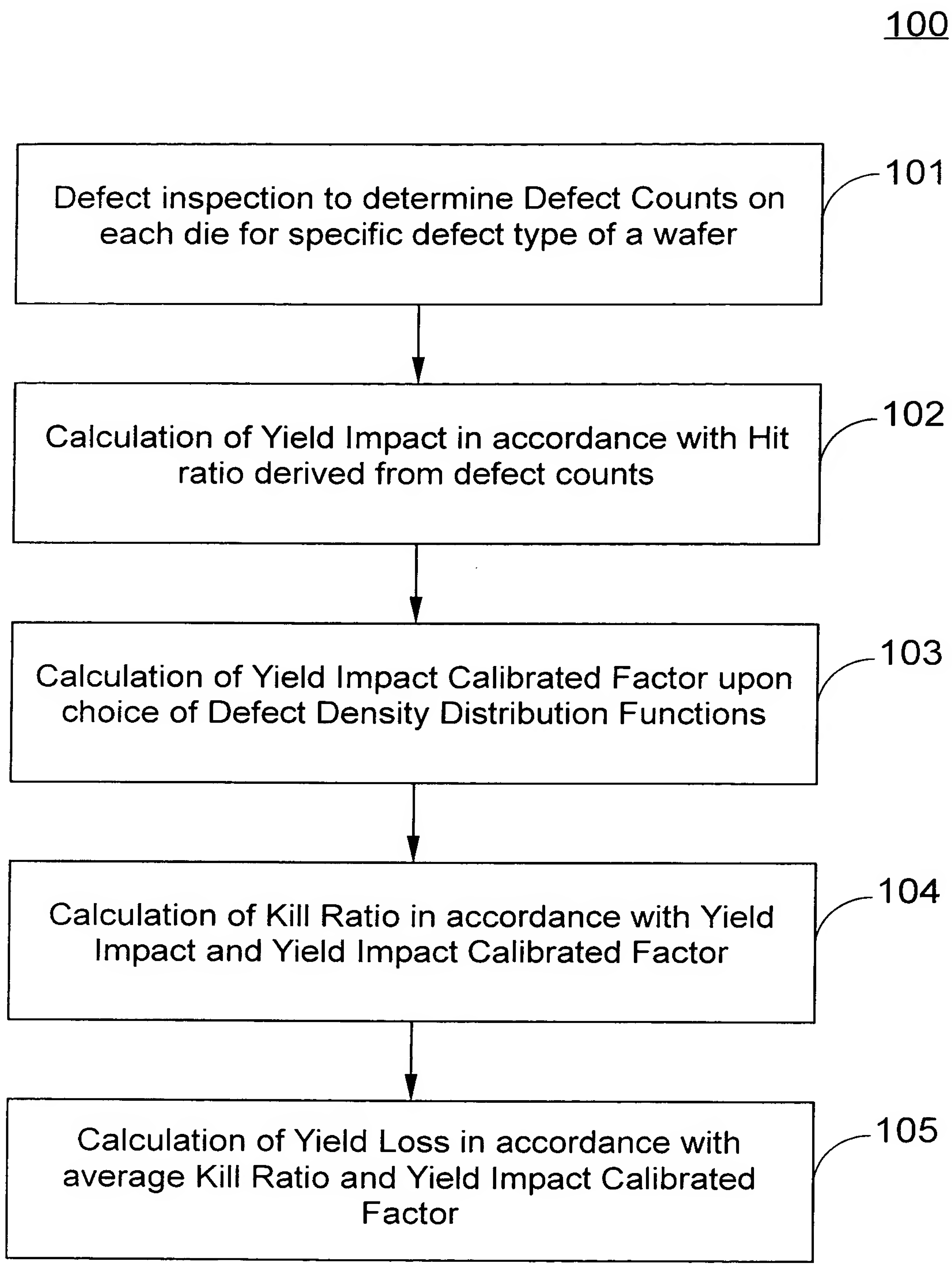

100
Defect inspection to determine Defect Counts on each die for specific defect type of a wafer
101
Calculation of Yield Impact in accordance with Hit ratio derived from defect counts
102
Calculation of Yield Impact Calibrated Factor upon choice of Defect Density Distribution Functions
103
Calculation of Kill Ratio in accordance with Yield Impact and Yield Impact Calibrated Factor
104
Calculation of Yield Loss in accordance with average Kill Ratio and Yield Impact Calibrated Factor
105

FIG. 1

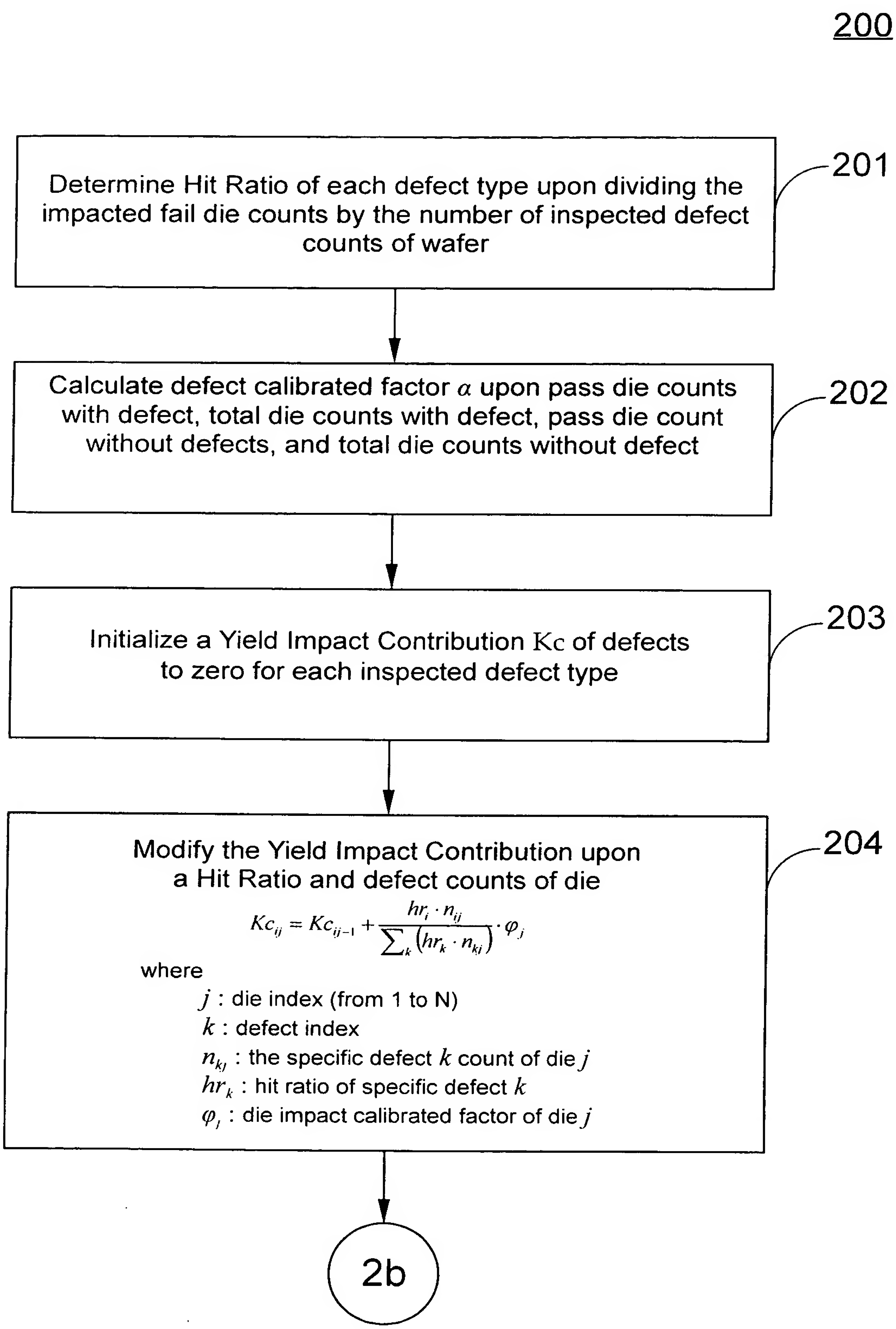

200
Determine Hit Ratio of each defect type upon dividing the impacted fail die counts by the number of inspected defect counts of wafer
201
Calculate defect calibrated factor α upon pass die counts with defect, total die counts with defect, pass die count without defects, and total die counts without defect
202
Initialize a Yield Impact Contribution Kc of defects to zero for each inspected defect type
203
Modify the Yield Impact Contribution upon a Hit Ratio and defect counts of die
$Kc_{ij} = Kc_{ij-1} + \frac{hr_i \cdot n_{ij}}{\sum_k (hr_k \cdot n_{ki})} \cdot \varphi_j$
where
j : die index (from 1 to N)
k : defect index
n_{kj} : the specific defect k count of die j
hr_k : hit ratio of specific defect k
φ_j : die impact calibrated factor of die j
204
2b

FIG. 2a

200

2a, 3

Calculate a Kill Ratio in accordance with Yield Impact Contribution Kc and calibrated factor β

$$Kr_{i0} = \frac{Kc_i}{(ND_{i0}A)\beta_i}$$

where

N : the total die count of wafer

D_{i0}: Average defect density per die for the specific defect i

A: the inspection area of the die

β_i: yield impact contribution calibrated factor

205

Calculate Yield Loss of defects for each inspected defect type on wafer

$$Y_i = Kr_{i0} \cdot [(D_{i0}A)\beta_i]$$

where

Kr_{i0}: the average kill ratio

N : the total die count of wafer

D_{i0}: average defect density of specific defect i

A : the inspection area of the die

β_i : yield impact contribution calibrated factor

206

FIG. 2b

300

Determine a Hit Ratio of each defect type from dividing the impacted fail die counts by the number of inspected defects obtained by die-based-sampling method — 301

↓

Determine defect calibrated factor α upon pass die counts with defect, total die counts with defect, pass die counts without defect, and total die counts without defect — 302

↓

Determine percentage ω of each defect type over Defect Review Sampling, where ω is obtained by dividing defect counts of specific type by the sum of defect counts of all inspected defect types — 303

↓

Determine the Yield Impact upon Hit Ratio and percentage of specific defect type — 304

$$Kc_i = K'c_i \cdot \alpha, \textit{where} \qquad K'c_i = \frac{hr_i \cdot \omega_i}{\sum_k (hr_k \cdot \omega_k)} \cdot n_f$$

where

k : defect code

n_f : fail die counts

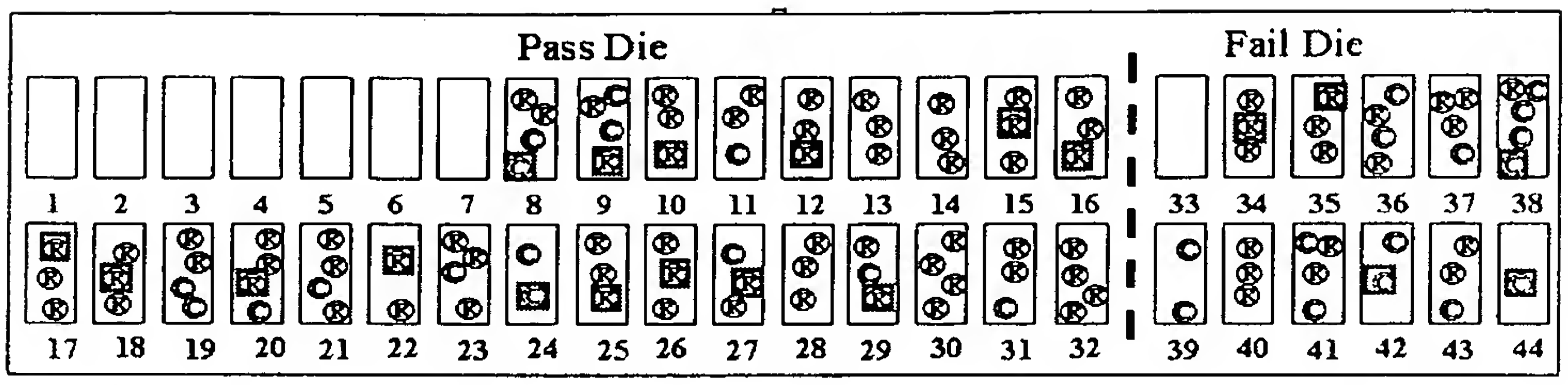
hr_k : hit ratio of specific defect k

ω_k : the percentage of specific defect k counts out of all inspected defect counts over defect review sampling

↓

2b

FIG. 3



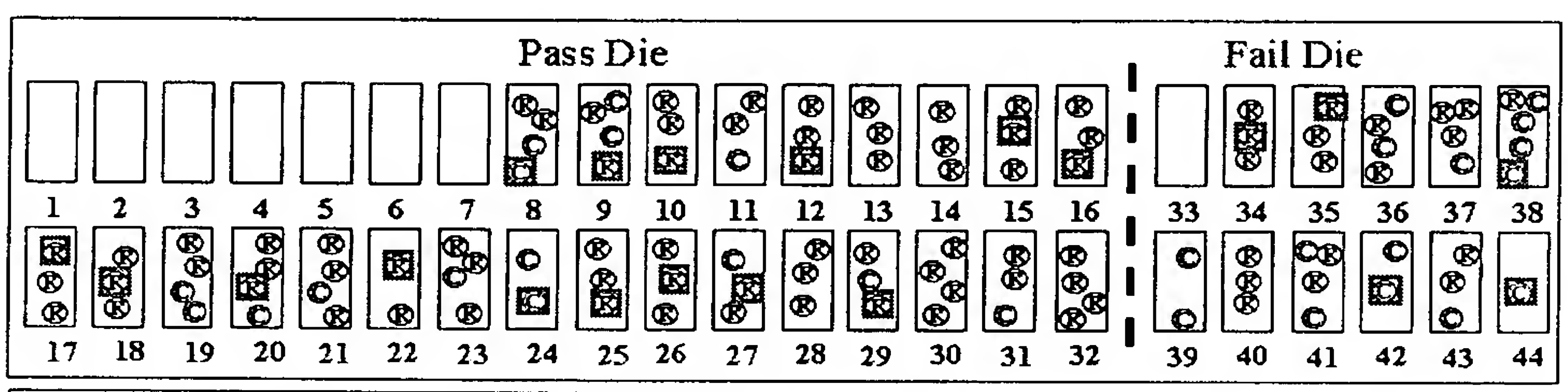
Real classification analysis :

1. hit rate : hr⊗ = 8/85 = 0.094, hr© = 8/30 = 0.267
2. defect contribution calibrated factor (α) : γ = 0.2063*[36/11] = 0.675
3. Start . Kc⊗,0 = 0, Kc©,0 = 0
4. Subsequently go through failed dies, modifying

Die 01 Kc⊗,01 = 0	Kc©,01 = 0
Die 02 : Kc⊗,02 = 0 + 0 = 0	Kc©,02 = 0 + 0 = 0
↓	↓
Die 31 . Kc⊗,31 = 0 + 0 = 0	Kc©,31 = 0 + 0 = 0
Die 32 : Kc⊗,32 = 0 + 0 = 0	Kc©,32 = 0 + 0 = 0
Die 33 : Kc⊗,33 = 0 + 0 = 0	Kc©,33 = 0 + 0 = 0
Die 34 · Kc⊗,34 = 0 + 1 = 1	Kc©,34 = 0 + 0 = 0
Die 35 . Kc⊗,35 = 1 + 1 = 2	Kc©,35 = 0 + 0 = 0
Die 36 : Kc⊗,36 = 2 + (0.094*2)/(0.094*2+0.267*2) = 2.260	Kc©,36 = 0 + (0.267*2)/(0.094*2+0.267*2) = 0.740
Die 37 : Kc⊗,37 = 2.260 + (0.094*3)/(0.094*3+0.267*1) = 2.774	Kc©,37 = 0.740 + (0.267*1)/(0.094*3+0.267*1) = 1.226
Die 38 · Kc⊗,38 = 2.774 + (0.094*1)/(0.094*1+0.267*4) = 2.855	Kc©,38 = 1.226 + (0.267*4)/(0.094*1+0.267*4) = 2.145
Die 39 : Kc⊗,39 = 2.855 + 0 = 2.855	Kc©,39 = 2.145 + 1 = 3.145
Die 40 : Kc⊗,40 = 2.855 + 1 = 3.855	Kc©,40 = 3.145 + 0 = 3.145
Die 41 · Kc⊗,41 = 3.855 + (0.094*2)/(0.094*2+0.267*2) = 4.115	Kc©,41 = 3.145 + (0.267*2)/(0.094*2+0.267*2) = 3.885
Die 42 : Kc⊗,42 = 4.115 + 0 = 4.115	Kc©,42 = 3.885 + 1 = 4.885
Die 43 : Kc⊗,43 = 4.115 + (0.094*2)/(0.094*2+0.267*1) = 4.528	Kc©,43 = 4.885 + (0.267*1)/(0.094*2+0.267*1) = 5.472
Die 44 · Kc⊗,44 = 4.528 + 0 = 4.528	Kc©,44 = 5.472 + 1 = 6.472
Modify: Kc⊗ = 4.528 * 0.675 = 3.056	Kc© = 6.472 * 0.675 = 4.369

5. If the defect distribution probability follow Poisson model's assumption, P(D) = D_0, see below
   Kr⊗ = 3.056/85 = 0.036, Kr© = 4.369/30 = 0.146

FIG. 4



⊗ DT MO PLY defect count : 85
© C2 ETCH PLY defect count : 30
□ classification sampling : 20 (⊗ : 15, © : 5)

Sampling classification model :

1. hit rate : hr⊗ = 2/15 = 0.133, hr© = 3/5 = 0.6
2. defect contribution calibrated factor (α) : γ = 0.2063*[36/11] = 0.675
3. ω⊗ = (15/20) = 0.75, ω© = (5/20) = 0.25
4. (hr⊗ * ω⊗)/(hr⊗ * ω⊗+hr© * ω©)= (0.75 * 0.133)/((0.75 * 0.133 + 0.25 * 0.6) = 0.400,
   (hr© * ω©)/(hr⊗ * ω⊗+hr© * ω©)=(0.25 * 0.6)/((0.75 * 0.133 + 0.25 * 0.6) = 0.600
   n_f = 11
5. Kc⊗ = 0.400 * 11 * 0.675 = 2.97, Kc© = 0.600 * 11 * 0.675 = 4.455
6. Kr⊗ = 2.97/85 = 0.035, Kr© = 4.455/30 = 0.149

FIG. 5

Table A. $f(D_{i0})$ Reference Table			
Condition (defect distribution probability function)	Author / Issued Year	Yield Model (Y_{die})	Yield Loss Model : $Y_{loss} = f(D_0)$
$P(D) = D_0$	Hofstein and Heiman / 1963	$Y_{die} = e^{-D_0 A}$	$Y_{loss} = (1 - e^{-D_0 A}) \cong D_0 A$
$P(D) = D / D_0^2$ *for* $0 \le D \le D_0$ $2 / D_0 - D / D_0^2$ *for* $0 \le D \le 2D_0$	Murphy / 1964	$Y_{die} = [(1 - e^{-D_0 A}) / D_0 A]^2$	$Y_{loss} = 1 - [(1 - e^{-D_0 A}) / D_0 A]^2$
$P(D) = e^{-D/D_0} / D_0$	Seeds / 1967	$Y_{die} = 1 / (1 + D_0 A)$	$Y_{loss} = 1 - [1 / (1 + D_0 A)]$

FIG. 6

average defect density per die	Seeds model (Yield loss)	Poisson model (Yield loss)
0.1	1.00	1
0.2	1.83	2
0.3	2.54	3
0.4	3.14	4
0.5	3.67	5
0.6	4.13	6
0.7	4.53	7
0.8	4.89	8
0.9	5.21	9
1	5.50	10
1.1	5.76	11
1.2	6.00	12
1.3	6.22	13
1.4	6.42	14
1.5	6.60	15
1.6	6.77	16
1.7	6.93	17
1.8	7.07	18
1.9	7.21	19
2	7.33	20

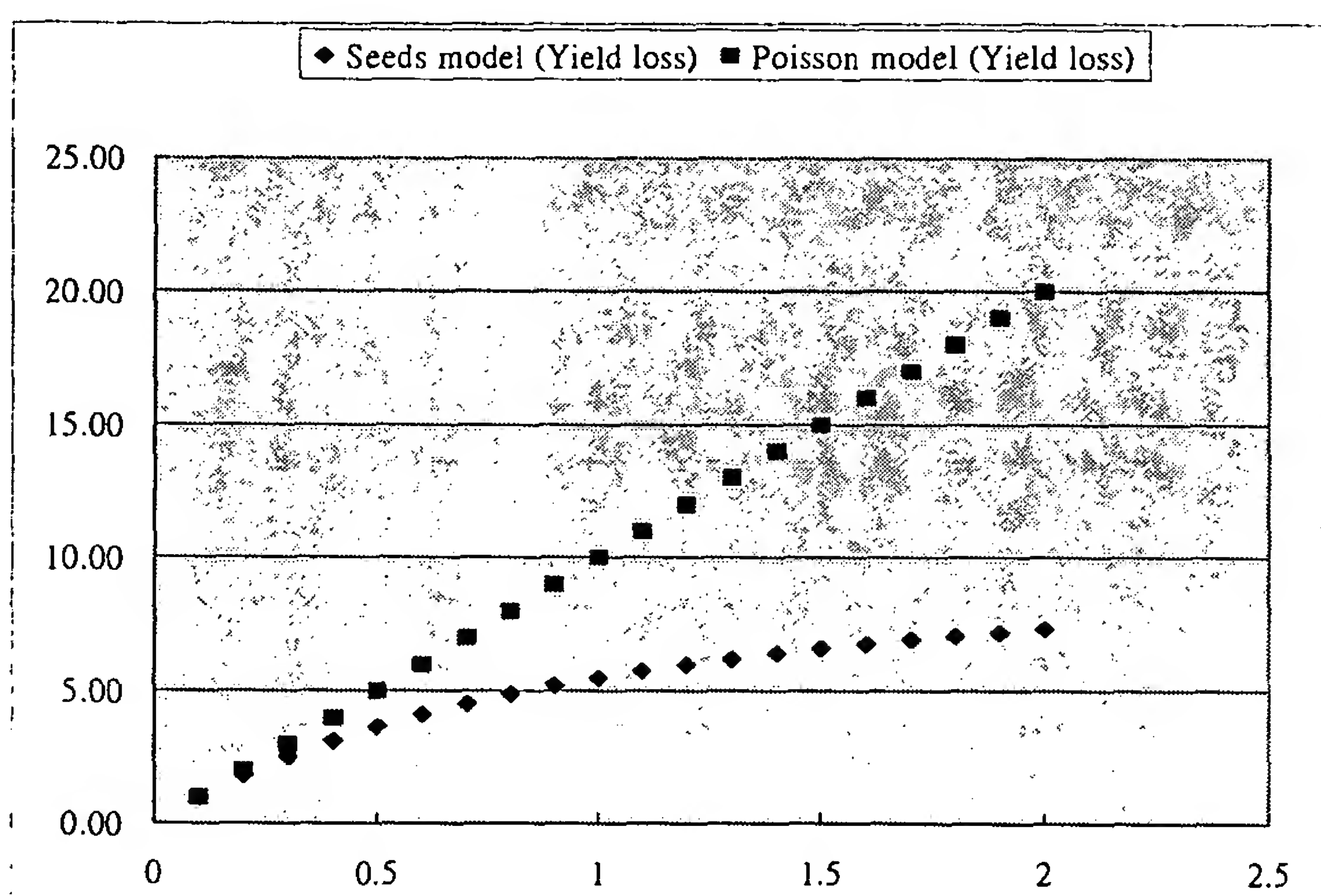


FIG. 7